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TITLE: METHOD AND APPARATUS FOR OPTICAL NETWORK MAINTENANCE TOOL

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METHOD AND APPARATUS FOR OPTICAL NETWORK MAINTENANCE TOOL

BACKGROUND OF THE INVENTION

1. Field of Invention

The present invention relates to optical networks and, more particularly, to methods and apparatus for the maintenance and analysis of an optical network.

2. Description of Related Art

Due to increased data traffic over public and private networks, fuelled in part by the rapid acceptance and reliance on the public Internet and the world wide web, the deployment of optical networks or optical network links has increased substantially. Further, due to the large bandwidth that is provided by these networks, any circumstance which detrimentally affects network performance will, in most instances, affect a tremendous amount of data. Additionally, due to the increased use of networking and data communication in general, users have developed an increased reliance on network availability. Moreover, users of data networks, including users of optical networks, have increasingly become less tolerant of any performance degradation or network down time.

With the increased deployment and use of optical networks comes an increased need for maintenance of these networks. The types of maintenance may include, for example, the need to assess a network's performance, troubleshooting, etc.

In many optical networks, maintenance and network performance assessment is performed manually. While a list of the network components or elements forming an optical network are typically known, the performance and configuration of each network element, which may change over time, is generally difficult to obtain. Current techniques

to determine optical network performance and configuration require a high degree of understanding of the network's operations and methodology. Additionally, as a result of manual steps required to gather, format and validate statistics collected for an optical network, there is a tremendous opportunity for errors to result. Moreover, manually performing these operations is extremely time consuming. It is estimated that analyzing an optical network comprising a forty (40) element ring may require approximately forty hours of time. As a result, this manual procedure of network analysis and maintenance is often unacceptable for a variety of reasons: the cost in time and money is too high, customers or users of the network usually require a quicker response and the quality of the analysis is often suspect due to the likelihood of errors caused by manually performing the analysis.

Additionally, due to difficulties in locating and employing qualified personnel to perform such maintenance and analysis, required or desired maintenance is often delayed or not performed. Moreover, without robust and accurate analysis, it is extremely difficult to "tune" or optimize an optical network for a customer.

Use of specially designed monitoring software which could be installed at each network element has been considered. However, use of such software may detrimentally impact the operation of the element itself. Moreover, the installation and maintenance of such monitoring software at each element in a network may result in additional maintenance and cost requirements.

Accordingly, it would be desirable to provide an optical network maintenance tool which addresses at least some of these shortcomings.

SUMMARY OF THE INVENTION

Advantageously, embodiments of the present invention provide an optical network maintenance tool which provides identification of elements forming parts of the network and, through utilization and analysis of data collected from each network element, an analysis of system configuration and performance can be provided.

Network elements, in many instances, individually collect data regarding optical fiber terminating at the network element. Embodiments of the present invention retrieve portions of the data collected in the normal course by network elements. This retrieved data may then be processed by embodiments of the present invention to generate a map of portions of an optical network. This map can then be populated with additional data relating to network element configuration and performance statistics of the optical fibers which terminate at the network element. This map can then be used by a wide variety of personnel in assessing the maintenance and operations of the mapped portions of the optical network.

In one aspect of the invention there is provided a method of mapping an optical network. The optical network comprising a plurality of network elements (NEs), some adjacent pairs of NEs of the plurality of NEs communicating using optical fibers and one or more of the some adjacent pairs forming optical links. The method comprising: identifying NEs which, together with optical fibers therebetween, form an optical link; organizing statistical data retrieved from each identified NE into a map which corresponds to the physical layout of the optical link.

In a further aspect of the invention there is provided a method for facilitating management of an optical network. The method comprising: over a network, querying a plurality of NEs for identification information; and correlating the identification information to identify NEs communicating over an optical link.

In a further aspect of the invention there is provided a computer readable medium operable to provide instructions for directing a processor to map a portion of an optical network. The instructions directing the processor to: identify NEs which, together with optical fibers therebetween, form an optical link; organize statistical data retrieved from each identified NE into a map which corresponds to the physical layout of the optical link.

In a further aspect of the invention there is provided an apparatus for generating a map of a portion of an optical network. The optical network comprising a plurality of network elements (NEs), some adjacent pairs of NEs of the plurality of NEs communicating using optical fibers and one or more of the some adjacent pairs forming optical links. The apparatus comprising: memory adapted to store computer readable instructions and code; a network interface adapted to communicate with a data network; a processor in communication with the memory and the network interface, the processor adapted to retrieve and execute the instructions and code from the memory adapting the processor to: identify NEs which, together with optical fibers therebetween, form an optical link; and organize statistical data retrieved from the NEs identified using the network interface into a map which corresponds to the physical layout of the optical link.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood with reference to the following detailed description read in conjunction with the drawings, in which:

FIG. 1	is a schematic illustration of a portion of an optical network embodying aspects of the present invention;
FIG. 2	is a schematic illustration of a portion of **FIG. 1**;
FIG. 3	is a schematic illustration of a portion **FIG. 2**;
FIG. 4	is a exemplary of computer terminal embodying further aspects of the invention, the computer terminal communicating with portion of the optical network of **FIG. 1**;
FIG. 4A	is exemplary of further aspects of the computer terminal illustrated in **FIG. 4**;
FIG. 5	is exemplary of data output resulting from communications between the computer terminal of **FIG. 4** and network elements of **FIG. 2**;
FIG. 6	is a schematic of a mapping of optical network of **FIG. 1** performed by the computer terminal of **FIG. 4**;
FIG. 7	is a flow chart of operations performed by the computer terminal of **FIG. 4**; and
FIG. 8	is a more detailed flow chart of a portion of the operations illustrated in **FIG. 5**.

DETAILED DESCRIPTION

Illustrated in **FIG. 1** is optical network **100** which embodies aspects of the present invention. Optical network **100** includes a Synchronized Optical NETwork (SONET) portion **120** and an Optical Service Channel (OSC) portion **130**. As persons of ordinary skill in the art are aware, network elements (NEs) forming part of the SONET layer are generally unaware of the OSC layer, and vice versa. SONET network **120** includes various SONET lines **104** and SONET section **106** (two such sections, **106A** and **106B**,

are illustrated). SONET lines **104** and sections **106** enable communication between SONET NEs **102** (three such NEs being illustrated – **102A**, **102B** and **102C**).

OSC network **130** includes optical links **108** (two such links, **108A** an **108B**, are illustrated) and computer terminal **110**. As illustrated in **FIG. 1**, computer **110** communicates with portions of links **108** through network **112**. Network **112** may be a conventional data network such as, for example, a public internet, private intranet, Ethernet, WAN, LAN or Public Switched Telephone Network (PSTN).

An OSC transmits a data communications channel (DCC) to NEs that do not process SONET overhead. The OSC also provides orderwire and power optimizer functionality and, in some instances, allows remote access for Operations, Administration, Maintenance and Provisioning (OAM&P) activities.

Communication between computer terminal **110** and an individual OSC NE of optical link **108** may use conventional networking protocols such as telnet, Ethernet, IP or the like. In the exemplary embodiment of **FIG. 1** computer terminal **110** communicates over a conventional PSTN using a modem. Alternatively, computer terminal **110** may connect directly to an OSC NE using, for example, serial communication.

An exemplary optical link – optical link **108A** – is illustrated in greater detail in **FIG. 2**. Optical link **108A** includes a number of NEs communicating over the OSC. These OSC NEs **202** (four are illustrated in **FIG. 2** – **202A**, **202B**, **202C** and **202D**) are in communication using optical fibers **204** (three optical fiber segments are illustrated – **204A**, **204B** and **204C**). Optical link **108A** is illustrated has having only a single optical fiber **204** for communication between adjacent OSC NEs **202**. However, as those of ordinary skill in the art will appreciate, many optical links **108** are provisioned with two optical fibers connecting adjacent OSC NEs **202**. Typically, in such a configuration, two

optical fibers **204** are provisioned between adjacent OSC NEs **202** to provide a level of redundancy should a single optical fiber **204** be damaged are otherwise go "offline". In the description herein, the optical links **108** described herein include only a single fiber between adjacent OSC NEs **202**. However, embodiments of the invention are equally applicable to adjacent OSC NEs **202** connected by one, two or more optical fibers **204**.

As will be appreciated by those of ordinary skill in the art, OSC NEs **202** are not "visible" to SONET NEs **102** (**FIG. 1**). The purpose of **FIG. 1** is provide an overview of an optical network **100** and the inclusion of both SONET NEs **102** (which are more common and more commonly appreciated) and the OSC NEs **202**. The embodiment of the maintenance tool described herein is adapted to assist in the maintenance and analysis of a portion of optical network **100**, namely the OSC optical links **108**.

Referencing **FIGS. 2** and **3**, an OSC NE **202** includes a circuit pack group (CPG) **320** which receives optical signals from optical fibers **204**. A CPG **310** receives optical signals from an optical fiber **204**, amplifies and conditions received signals, and re-transmits these optical signals on an optical fiber **204**. Each optical fiber **204** is used for bi-directional communication. Consequently, two bands of optical signals – a red band (having wavelengths of approximately 1547.50 – 1561.00 nm) and a blue band (having wavelengths of approximately 1527.50 – 1542.50 nm) – are transmitted on each optical fiber **204**. As will be appreciated by those of ordinary skill in the art, an OSC NE **202** may be configured as a terminating end of an optical link **108** (such as OSC NEs **202A** and **202D**) or as a Mid-Span Access (MSA) element (such as OSC NEs **202B** and **202C**). Accordingly, a single OSC NE **202** may communicate with an adjacent OSC NEs 202 using one, two or more optical fibers **204**.

A CPG **320** receives incoming optical signals from the red band **308A** and in the blue band **310A**. Received optical signals **308A** and **310A** are amplified by amplifiers **304A**

and **304B**, respectively. For bi-directional optical fibers **204** using more than one waveband, these amplifiers are sometimes known in the art as Multi-wavelength Optical Repeaters (MORs). A CPG **320** may provide additional signal conditioning. The type of signal conditioning provided is configurable and is known in the art as the facility **306** of the CPG **320**.

Once a received red or blue band optical signal **308A**, **310A** has been amplified and (possibly) conditioned, the output red and blue band optical signals are output as red band output signals **308B** and blue band output signals **310B**.

As will be appreciated by those of ordinary skill in the art, OSC NEs **202** can, and often are, configured to collect data (e.g., statistics and other information) regarding the optical signals (red and blue bands) received, amplified (and, possibly, conditioned) and output on optical fibers **204**. In the preferred embodiment, each OSC NE **202** will maintain records or data relating to communication with other OSC NEs **202** forming part of an optical link **108** (e.g., the identities of other OSC NEs, optical fiber performance, etc.). Additionally, each OSC NEs **202** will also preferably be suitably configured or modified to enable retrieval of the records maintained.

Embodiments of the invention include conventional OSC NEs **202** preferably modified to communicate with computer terminal **110** over network **112** as described herein. However, if OSC NEs **202** are not configured to communicate remotely with computer terminal **110**, each OSC NEs **202** should be configured to enable retrieval of records maintained through other methods (e.g., serial link communication).

Computer terminal **110**, an embodiment of which is illustrated in **FIG. 4**, includes a processor **110** in communication, via a suitable bus, with input/output (I/O) card **404**,

memory **416** and network interface (I/F) **414**. Memory **416** may include both volatile memory **406** and persistent memory or storage **408**.

Processor **110** is a central processing unit (CPU) and associated chip set suitable to perform the operations attributed to computer terminal **110** described herein. For example, processor **402** may be implemented using a conventional processor such as Intel Pentium-class processor, reduced instruction set computer (RISC) chip or the like. Additionally, and as will be appreciated by those of ordinary skill in the art, one or more CPUs may be employed in alternative embodiments. Memory **406** may include conventional RAM, ROM, FLASH and other similar suitable storage devices for storing computer instructions, code and temporary data registers. Persistent storage **408** may include both internal and external storage devices such as fixed or hard disk drives, ZIP™ disks, optical storage devices (e.g., DVD-RAM, RW-CD, etc.) and the like. Memory **406** and persistent storage **408**, in part or in whole, operate as a computer readable medium for the storage and retrieval of computer instructions and codes which adapt processor **402** to perform the functions and operations described herein.

Network I/F **414** enables communication between computer terminal **110** and other networking devices (e.g., OSC NEs **202**) over a suitable network connection such as network **112** (**FIG. 1**). In the exemplary embodiment, network I/F **414** is a modem, Ethernet card or other suitable device for enabling communication with network **112** (**FIG. 1**). Alternatively, computer terminal **110** may communicate with other networking devices directly over a suitable link such as an RS-232 cable. In such an embodiment, network I/F **414** may be embodied in a serial port.

I/O card **404** provides a suitable interface between a user and computer terminal **110** and enables computer terminal **110** to receive computer instructions, code or the like. Accordingly, I/O card **404** communicates with input/output devices **410** which may

include a keyboard, a mouse, a display or the like. I/O card **404** may be adapted to receive user instructions in the form of keyboard entries or mouse clicks indicative of user selections. Additionally, I/O card **404** provides an interface between computer terminal **110** and an external computer readable medium **412** which may be embodied in a diskette, CD-ROM or the like.

Memory **416** is illustrated schematically and in greater detail in **FIG. 4A**. As will be appreciated by those of ordinary skill in the art, the functional delineations illustrated in **FIG. 4A** may be altered and functions combined or separated as required. Memory **416**, which may include both volatile and persistent memory **406**, **408**, includes an operating system (O/S) **420**, communication software (S/W) **430**, maintenance tool S/W **440** and a data portion **450**.

O/S **420** may be implemented using a conventional operating system such as, for example, Microsoft™ Windows™ 98, 2000 ME, NT, Linux, Unix or the like.

Communication S/W **430** operates in conjunction with O/S **420** and maintenance tool **440** to enable communication between computer terminal **110** (**FIGS. 1** and **4**) and OSC NEs **202** through network **112** or, in an alternative embodiment, through direct serial communication. In the illustrated embodiment, communication S/W **430** operates to utilize the hardware facilities of network I/F **414**. Accordingly, communication S/W **430** in the illustrated embodiment may include known communication protocols such as the telnet, Ethernet or Internet protocols. Additionally or alternatively, communication S/W **430** may include software to operate a modem.

Maintenance tool **440** is, in the exemplary embodiment, software instructions or codes which, when retrieved from memory **416** and executed by processor **402** adapt

processor **402** to perform the functions described herein including those illustrated as flow charts in **FIGS. 7-8**.

In **FIGS. 7** and **8** (with reference to **FIGS. 4**, **4A**, **5** and **6**) maintenance tool **440** adapts processor **402** to perform operations **700**. Hereinafter description of the exemplary embodiment will refer to operations and functions performed by maintenance tool **440**. While it is more accurate to indicate that the computer readable instructions or codes (illustrated in flow charts of **FIGS. 7** and **8**) which form maintenance tool **440** are retrieved from memory **416** and executed by processor **402** thus adapting processor **402** to perform these functions, to be more concise these operations and functions will be attributed directly to maintenance tool **440**.

During operations **700**, maintenance tool **440** will operate to communicate with and collect data from each OSC NE **202** that forms part optical network **100** (**FIG. 1**). Communication between maintenance tool **440** and an OSC NE **202** is facilitated through operation of communication S/W **430** and network I/F **414**. Communication between maintenance tool **440** and the OSC NEs **202** may be conducted in a serial or parallel manner. That is, maintenance tool **440** may first communicate with and collect data from a first OSC NE **202**. Subsequent to communication with a first OSC NE **202**, maintenance tool **440** may then repeat the communication and collection with a second OSC NE **202**. This communication and collection may then be repeated as necessary. Alternatively, maintenance tool **440** may communicate with and collect data from more than one OSC NE **202** simultaneously or contemporaneously (i.e., in parallel). In the exemplary embodiment, maintenance tool **440** operates to communicate with and collect data from a plurality of OSC NEs **202** serially.

Regardless of the communication protocols used to establish communication or whether communication with OSC NEs **202** is established in a serial or parallel fashion, data is

collected from each OSC NE **202** (**S702**). The data collected from each OSC NE **202** is used by maintenance tool **440** to determine the identity of each OSC NE **202** in a single band (i.e., red or blue band) forming part of a single optical link **108**. Once the identities of the OSC NEs **202** for a single optical link **108** are determined, maintenance tool **440** uses this identity information to associate information related to the red band of a single optical link **108** with the information related to the corresponding blue band thus forming an "optical link pair" (**S704**). Using the information of the optical link pair, maintenance tool **440** forms a map or detailed description of the entire optical link **108** which can then be presented to a user (**S706**).

As described above, data used, in part, by maintenance tool **440** to generate a detailed map of optical links in optical network **100** is collected from individual OSC NEs **202**. The data or information collected is, in the exemplary embodiment, data that is typically generated and stored by each OSC NEs **202** for various other purposes. Accordingly, in one aspect of the present invention, data required by maintenance tool **440** can be accessed using conventional tools. For example, in optical networks employing OSC NEs from Nortel Networks Ltd. of Brampton, Canada, data required by maintenance tool **440** can be accessed by using a tool known as the Multi-wavelength Optical Repeater Facility (MORF) software. As will be appreciated by those of ordinary skill in the art, other software from other suppliers of OSC NEs or custom software could be employed to retrieve similar data from OSC NEs. However, in the embodiments described herein, reference will be made to the MORF software which forms part of or is used by maintenance tool **440**.

Using a list of the network addresses, network IDs or physical locations of the individual OSC NEs **202** (which may be manually provisioned into memory **416** of computer terminal **110** – **FIG. 4**), maintenance tool **440** will establish communication with each OSC NE **202** (**S702**). During communication, maintenance tool **440**, through utilization

of the MORF software (or other suitable software), will query and retrieve data records maintained by each NE **202**. The data retrieved from an OSC NE **202** will generally include, but not be limited to, data **500** illustrated in **FIG. 5**.

Data for fields **502**, **504** and **506** can be obtained using the MORF software with the following command lines: "morf pwrm disptr g0 red" (which generates data **500** for the red band) and "morf pwrm disptr g0 blue" (which generates data **500** for the blue band).

Data **500** includes information or indicia pertaining to the identity **502** (e.g., NE ID) of each OSC NE **202** with which the queried NE has communicated, the identity of the CPG **504** corresponding to each identified NE and the configuration **506** of the amplifier (or MOR). Rows of data **508** (having data fields NE ID **502**, MOR CPG **504** and MOR configuration **506**) are retrieved from each OSC NE **202** forming part of optical network **100** (**FIG. 1**). Since a single OSC NE **202** may operate as a mutli-span access unit, a single OSC NE **202**, in a non-redundant optical link (i.e., an optical link with only one optical fiber connecting adjacent NEs), may service more than one optical fiber **204**. Consequently, a single OSC NE **202** may be identified twice in data **500** retrieved from a single OSC NE **202** – once for each optical fiber **204** serviced. For those NEs listed twice in data field **502** of data **500**, one amplifier **304** (**FIG. 3**) will be configured as an MSA pre-amplifier (MSAPre) and the other amplifier **304** will be configured as an MSA post-amplifier (MSAPost) in column **506**.

As will be explained below, other data, in addition to that collected from fields **502**, **504** and **506**, will also be collected from each OSC NE **202** and stored for later processing in memory **416**. This data can be obtained through the MORF software using the following command lines: "morf pwrm disptp g0 red" (which returns data relating to power measurements and, more particularly to input red power, reflected blue power, input OSC power, total input power, output red power, output OSC power, total output power,

input LOS threshold and input shut-off threshold) and "morf pwrm disptp g0 blue" (which returns similar data for the blue band). Other calls to the MORF software may be made to collect additional data from the queried OSC NE **202**. These calls may include, for example, "morf pwrm dispor g2 red" or "morf pwrm dispor g2 blue" (each of which returns data relating to output optical return loss, optical return loss threshold and optical reflectometer state relating to the specified color band); "morf sig qrgp g0 red" and "morf sig qrgp g0 blue" (each of which returns data relating to amplifier configuration, fiber type, power control mode, input shut-off mode, color band output optical reflectometer, total output power target, peak output power target, input LOS threshold, input shut-off threshold, optical return loss threshold, mid-stage access partner and output power lock for the respective color band); and "morf sig disptp" (which returns data relating to output optical return loss).

Since an OSC NE **202** will only communicate with other OSC NEs **202** forming part of the same optical link **108**, maintenance tool **440**, having retrieved data **500** from each OSC NE **202** forming at least part of optical network **100** (**FIG. 1**), collates the data collected to determine the OSC NE members of optical links **108** for each band (red or blue). This collation may be performed by selecting one OSC NE **202** of an optical link **108**. For the selected OSC NE **202**, data **500** retrieved will identify one or more (and usually all) members of its optical link **108**. By accessing similar data for each of these members identified in data **500** (and the data **500** retrieved from those OSC NEs **202** identified by the data from the selected OSC NE and so on), a complete listing of the members of a single optical link **108** can be generated. Accordingly, a listing **600** (**FIG. 6**) of each OSC NE **202** forming optical links **108** can be generated. This process can then be repeated for other OCS NEs **202** forming other optical links **108**.

It should be noted that listing **600** provides an excellent cross-check against the initial listing of addresses OSC NEs **202** forming optical network **100**. If, for whatever reason,

modifications or alterations to optical network **100** (and, more particularly, the OSC portion) have been made without updating the initial listing of OSC NE **202** addresses used by maintenance tool **440**, listing **600** can identify this problem. As described above, listing **600** will be generated from records maintained by each OSC NE **202**. These records include the NE ID of other OSC NEs which have communicated with the selected OSC NE. Accordingly, the records used to generate listing **600** may include NE IDs which did not form part of the initial listing but which identify NEs which have communicated with a selected OSC NE **202**. Any discrepancy between the initial listing and listing **600** will, in some embodiments, result in maintenance tool **440** updating the initial listing for future reference; contacting any OSC NE **202** missing from the initial listing, and collecting any desired information. Alternatively, maintenance tool **440** may indicate the discrepancy to a user of maintenance tool **440** by way of message, alarm or the like.

Since the MORF software used by maintenance tool **440** is waveband specific, data corresponding to optical links **108** will be separated into data corresponding to the red band portion of optical links **108** (illustrated in **FIG. 6** as red band optical link data structures **604** – a data structure representing three red band optical links are illustrated as data structures **604A**, **604B** and **604C**) and the blue band portion of optical links **108** (illustrated in **FIG. 6** as blue band optical link data structure **606** – data structures representing three blue band optical links are illustrated as data structures **606A**, **606B** and **606C**).

Each data structure **604**, **606** will include data blocks **608**, **610**, respectively, corresponding to individual OSC NEs **202** which form part of an optical link **108**. As will be appreciated, data structures **604**, **606** may vary in the number of data blocks **608**, **610** depending upon the number of OSC NEs **202** which form part of a corresponding optical link **108**. For example, the red band data structure **604** corresponding to optical

link **108A** (**FIG. 1**) will include four data blocks **608** – one for each of the four OSC NEs **202** illustrated. A similar number of data blocks **610** will be included in the blue band data structure **606** corresponding to optical link **108A**. In contrast, the red and blue band data structures **604**, **606** corresponding to optical link **108B** will each include only three data blocks **608**, **610**, respectively. Accordingly, the size (i.e., the number of data blocks) in a selected data structure **604**, **606** may differ from the size another data structure **604**, **606**.

A data structure for a single band portion of single optical link (e.g., **604A** or **606A**) will initially include a data block **608**, **610** representing the OSC NE ID (from field **502** – **FIG. 5**) and the MOR CPG number (from field **504** – **FIG. 5**). In combination these two fields of data will uniquely identify one amplifier **304** (**FIG. 3**) of a single OSC NE **202** (**FIG. 2**).

In addition to generating data blocks **608**, **610** and arranging these data blocks in data structures **604**, **606** based on color band for each optical link **108**, maintenance tool **440** arranges for the data blocks **608**, **610** of data structures **604**, **606** to be organized in an order which mimics or corresponds to the physical layout of the corresponding optical link **108**. Structures **604**, **606** are arranged based on the data received from the "morf pwrm disptr g0 red" and "morf pwrm disptr g0 blue" commands.

Once the red and blue band optical link data structures **604**, **606** have been generated and the data blocks **608**, **610** contained therein are organized to mimic the physical layout of a corresponding optical link **108**, maintenance tool **440** performs operation **S704** (**FIG. 7**) to associate the two band data structures **604**, **606** which form a single optical link **108**. Operation **S704** is illustrated in greater detail in the flow chart of **FIG. 8**.

Operation **S704** is performed by maintenance tool **440** once for each red band optical link data structure **604** generated in **S702**. Accordingly, and in the exemplary

embodiment, a loop (**S804-S826**), having a counter (i) set to zero (**S802**) that is incremented by one for each pass through the loop (**S826**), is performed for each band optical link data structure **604**. Once the value of "i" exceeds the number of red band data structures (**S804**), operations **S704** terminate.

For each i^{th} red band data structure **604**, a second loop (**S808-824**) is performed. The second loop is performed at most once for each blue band data structure **606** by using a second counter "j". Like the first loop, the second loop terminates once the counter "j" has exceeded the number of blue band data structures **606** (**S808**). The second loop may also terminate early (i.e., prior to counter "j" exceeding the number of blue band data structures **604**) if a blue band data structure **606** is identified which corresponds to the i^{th} red band data structure **604** (**S824**). If, during a pass through the second loop, maintenance tool **440** determines that the j^{th} blue band data structure **606** is the same size (i.e., has the same number of data blocks **610**) as the i^{th} red band data structure **604** (**S810**), a third loop (**S816-822**) is performed using a counter "k". If, however, the size of the j^{th} blue band data structure **606** is different from the size of the i^{th} red band data structure **604**, counter "j" is incremented (**S812**) and the second loop repeats until a blue band data structure **606** having the same size as the i^{th} red band data structure **604** is identified.

If the j^{th} blue band data structure **606** is the same size as red band data structure **604**, the third loop (**S816-822**) is performed once for each k^{th} data block **608, 610** in the corresponding data structures **604, 606**. During the third loop, the OSC NE IDs and the CPGs (which were previously retrieved in **S702 – FIG. 7**) for each data block are compared. If, for each k^{th} data block **608** in the i^{th} red band data structure **604**, there exists a data block **610** in the identified j^{th} blue band data structure **606** which has the same NE ID and CPG (**S822**), then the two data structures **604, 606** are associated with each other since both data structures refer to the same optical link **108** (**S824**). In this

circumstance, the second and third loops terminate, the counter "i" is incremented by one (**S826**) and the first, second and third loops repeat for the remaining red band data structures **604**.

As a consequence of operation **S704** and, more particularly operations **S802-S828**, for each optical link **108**, which transmits red and blue band data signals, the corresponding one red band data structure **604** and corresponding one blue band data structure **606** of a single optical link **108** will be associated with each other.

However, and as indicated above, in some optical networks redundant optical fibers are sometimes used to provide additional security and availability. In such a redundant optical network, adjacent pairs of OSC NEs **202** communicate via two (or more) optical fibers **204**. As a result of this redundancy, a single optical link **108** may be associated with more than one pair of corresponding red and blue band data structures **604**, **606** (i.e., for a single redundant system which has two optical fibers **204** connecting adjacent pairs of OSC NEs **202**, there would be two pairs of red and blue band data structures **604**, **606**). Accordingly, in some embodiments of the present invention, it may be desirable to associate all pairs of red and blue band optical structures for the same optical link **108**. The association of all pairs of red and blue band optical structures for the same optical link **108** may be enabled by using an algorithm similar to that illustrated in **FIG. 8**.

As indicated above, in addition to the NE ID, CPG number and MOR configuration data collected from fields **502**, **504** and **506** (**FIG. 5**), other data is also collected by maintenance tool **440** and stored in memory **416** of computer terminal **110**. This stored data, previously unused, is used to populate each of data blocks **408**, **410** with performance and configuration data for each OSC NE **202** associated with data blocks **408**, **410** (**S706**).

If desired, the data blocks **408**, **410** can then be output to a user in a desired format. This may, for example, include displaying the results in textual or graphical form on output device **110** (**FIG. 1**)(e.g., a display or printing device), outputting the data to a computer readable format such as memory **416**, medium **412** (**FIG. 4**) or the like. For example, a graphical representation of the individual links may be presented on a display by I/O card **404** (**FIG. 4**). By passing a pointer (through use of a mouse) over any graphical representation of an OSC NE **202**, a user may be presented with a "pop-up" message box containing all or some of the performance and maintenance statistics relating to the selected OSC NE. Alternatively, output to memory **416** or medium **412** may be provided in a format that is readable by other computer applications such as Microsoft™ Excel™. In this latter instance, a comma or tab delimited format may be preferred.

As will be appreciated by those of ordinary skill in the art, an optical network is provided which includes a tool (e.g., maintenance tool **440**) which enables simple, remote and easy to use analysis of portions of the optical network. Embodiments of the invention are estimated to provide significant cost and time savings over known maintenance and analysis methods. Additionally, embodiments of the present invention reduce the errors (as compared the manual system), timely responses to maintenance and analysis and, additionally, requires relatively little user skills or involvement.

While one (or more) embodiment(s) of this invention has been illustrated in the accompanying drawings and described above, it will be evident to those skilled in the art that changes and modifications may be made therein without departing from the invention. All such modifications or variations are believed to be within the scope of the invention as defined by the claims appended hereto.